

REMARKS

Claims 27 - 31 remain active in this application. New claims 32 - 35 have been added to more fully recite the subject matter considered to be the invention. Support for the new claims is found throughout the specification and drawings and at page 12, line 18, in particular. A minor editorial revision has been made, as required, on page 16. No new matter has been introduced into the application.

The Examiner has objected to the drawings as failing to illustrate "a supplemental protective layer..." and required correction. This objection and requirement are respectfully traversed.

In response, the Examiner's attention is respectfully called to the paragraph bridging pages 16 and 17 of the specification in which it is stated that "layers 34-37 may be considered to represent a multi-layer structure containing an optional nitridized layer and the oxidized layer, or an oxynitride layer" and that the "nitridized layer acts as a supplementary barrier". Thus, as disclosed, the supplemental protective layer is, in fact, well-illustrated by multi-layer structures 37-40. Accordingly, since structures 37-40 include the supplemental barrier, reconsideration and withdrawal of this objection and requirement are respectfully requested.

The Examiner has also objected to the specification at page 16, line 14, and criticized the language at page 12, lines 4 - 5; requiring appropriate correction. These objections are respectfully traversed as being moot in view of the amendment made above.

In regard to page 16, line 14, a typographical revision has been made at the point of the Examiner's criticism. In regard to the criticism of page 12, lines 4 and 5, it is believed that no grammatical error

is present. The sense of the passage is: Further, [if] extrusion were to be of concern in the structure here... (emphasis added). Therefore, the verb form seems to be correct and the syntax appropriate and clear. Therefore, it is respectfully submitted that no correction is required. However, authorization is hereby given to conform the language of the passage to that indicated above by Examiner's Amendment if the Examiner persists in the stated criticism.

Accordingly, it is respectfully submitted that the foregoing is fully responsive to the Examiner's objection and requirement and reconsideration and withdrawal thereof, with or without an Examiner's Amendment, is respectfully requested.

Claim 27 has been rejected under 35 USC §102 as being anticipated by Bai et al.; Claims 27 - 28 have been rejected under 35 USC §102 as being anticipated by Lopatin et al.; Claims 29 - 30 have been rejected under 35 USC §103 as being unpatentable over Lopatin et al. in view of Yew et al.; and claim 31 has been rejected under 35 USC 103 as being unpatentable over Lopatin et al. or Bai et al. in view of Kawanoue et al. All of the grounds of rejection are respectfully traversed.

The claimed invention comprises a combination of elements including, *inter alia*, a layer of flowable oxide which is susceptible to damage through a variety of mechanisms and agents and two "protective" or "barrier" (claim 32) layers for protecting the flowable oxide, each having particular properties such as the first protective layer preventing exposure of the flowable oxide to moisture and resist developers and "impervious to copper extrusion" and the second protective layer being electrically conductive. Known conductive protective layers such as tantalum/tantalum nitride systems are known to have micro-defects such as pinholes which will allow copper extrusion. Dielectric protective layers previously employed, to be effective,

have been of thicknesses which severely increase the dielectric constant of the insulating material to dilute the beneficial effects of special low-K dielectrics such as flowable oxides used to limit capacitance between closely spaced conductors and which introduce adhesion problems at the dielectric-metal interface and/or limit the cross-sectional area of conductive material which can be employed. Thus, the combination of two protective layers of different properties in accordance with the invention provides improved protection from copper extrusion without significant compromise of low-K properties of modern flowable oxide dielectrics which could not previously be successfully used for support of wiring metallization in damascene structures without severe compromise of manufacturing yield and/or the electrical characteristics of the structures.

Bai et al. teaches only a single protective/barrier layer 31, 42 for a silicon dioxide dielectric (i.e. neither low-K nor flowable, as disclosed) in combination with a capturing layer 36, 43 which is reactive with the metal material of connections. Preferred barrier layer materials are listed at column 5, lines 30 - 36, and are essentially metal/metal nitride systems similar to those discussed as admitted prior art and which are subject to micro-defects. Titanium is suggested (column 8, line 45) for capturing layer 36 and certainly is not "impervious to copper extrusions" since the copper is reacted within the body of the capturing layer as shown at 33, 34 and 35 of Figure 3. There is no teaching or suggestion or need for protection of a flowable oxide from resist developers since a silicon dioxide dielectric is used. Therefore, claim 27 is not anticipated by Bai et al.

Lopatin et al. similarly teaches only a single barrier layer 123 which is a Ta/TaN system (subject to micro-defects) in combination with oxide and nitride

dielectric layers which are not taught to be subject to damage from resist developers. Layer 124 is a seed layer of tungsten or cobalt/tungsten to assist in metal deposition for conductor 102/120 and not a second protective layer. Therefore, Lopatin et al. does not anticipate claim 27 or 28.

Yew et al. suggests use of a high-K inorganic material for hard mask 214 without any protective layers for dielectric 212 and thus does not supplement the teachings of Lopatin et al. in regard to providing two complementary protective/barrier layers. Neither recognizes the problem addressed by the invention or provides a solution thereto or leads to an expectation of success in achieving the meritorious effects of the invention. Thus the combination of Lopatin et al. and Yew et al. does not provide evidence of a level of skill in the art which would support the conclusion of obviousness that the Examiner has stated and a *prima facie* demonstration of obviousness cannot be made based on the combined teachings thereof. Therefore, the rejection of claims 29 and 30 based on Lopatin et al. and Yew et al. is clearly in error and improper.

Kawanoue et al. is directed to a multi-layer protective structure wherein the layers are metal, metal-containing materials including boron, carbon, oxygen and nitrogen and oxides, nitrides and oxynitrides of those materials in order to provide a barrier layer consistent with low resistance. again, the dielectric appears to be silicon dioxide (column 14, line 41) which is not subject to damage by moisture or resist developers or of low-K; the effects of which it is desirable to preserve. Therefore, Kawanoue et al. does not, in fact, teach or suggest a supplemental protective layer on the primary protective layer or teach complementary protective layers which improve protection from copper extrusion and moisture while avoiding damage to a flowable oxide layer without

compromise of the low-K characteristics of the latter or, in fact, teach or suggest anything corresponding to the claimed first protective layer. Therefore, the rejection based on Lopatin et al. or Bai et al. in view of Kawanoue et al. is clearly in error and unsupported by the references relied upon either by teachings or suggestions contained therein or the level of ordinary skill in the art which can be discerned therefrom. The Examiner has not made a *prima facie* demonstration of obviousness of the subject matter of claim 31 (or any other claim) based on these references and it is respectfully submitted that none can be made.

Accordingly, it is respectfully submitted that all of the stated grounds of rejection are in error and improper and without proper basis in the prior art relied upon. Therefore reconsideration and withdrawal of all of the rejections of record is respectfully requested.

It is also respectfully submitted that all of new dependent claims 32 - 35 are similarly allowable over the prior art of record by reason of the allowability of the claims from which they depend, as discussed above and, further, by virtue of the additional recitations respectively contained therein. For example, the prior art of record does not teach the first protective layer having the properties recited in claim 27 to be a barrier layer as recited in claim 32, a maximum thickness of the first barrier layer relative to the thickness of the flowable oxide layer as recited in claims 33 and 35 or that the flowable oxide layer is a low-K dielectric, as recited in claim 34. Therefore, it is believed that these claims amply and clearly distinguish from the prior art of record.

Since all rejections, objections and requirements contained in the outstanding official action have been fully answered and shown to be in error and/or inapplicable to the present claims, it is respectfully

submitted that reconsideration is now in order under the provisions of 37 C.F.R. §1.111(b) and such reconsideration is respectfully requested. Upon reconsideration, it is also respectfully submitted that this application is in condition for allowance and such action is therefore respectfully requested.

A petition for a two-month extension of time for response and fee therefor is being concurrently filed herewith. If any further extension of time is required for this response to be considered as being timely filed, a conditional petition is hereby made for such extension of time. Please charge any deficiencies in fees and credit any overpayment of fees to Deposit Account No. 09-0458 of International Business Machines Corporation (Fishkill).

Respectfully submitted,



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APPENDIX

Page 16, line 3+:

It should be noted that a protective layer will also be formed on the first FOX layer 22 by reactive ion etching with flourocarbon gases (RIE). Since those of skill in the art often etch a trench such as the conductor troughs 26a and 26b by a fluorocarbon RIE, it should be apparent that first oxidized sidewalls 37-40 may be formed during etching of the conductor troughs 26a and 26b. However, as previously mentioned, it is preferred to form the first oxidized sidewalls 37-40 in a separate step because a greater degree of control is thus obtained. If the first oxidized sidewalls [3740] 37-40 are formed during the RIE. it is believed that lesser control would result in an alteration of the profile of the first sidewalls 33-36 due to the removal of some of the material in the first FOX insulator layer 22.